Status Report No. 7 on Grant NASA-NSG-224-61

to

National Aeronautics and

Space Administration

from

Department of Physics

Florida State University

Radio Astronomy Programme

Period

February 1, 1965 through July 31, 1965

Submitted by

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Principal Investigator

ABSTRACT

The Radio Observatory is being moved to a new and quieter site several miles south of Tallahassee and a subsidiary site is being arranged some six miles away in the National Forest area. Arrangements for the new spaced-site polarization experiment are well under way, and it is hoped that observations will begin during September, 1965. Existing equipment will be in operation a little earlier.

The North-South line of overseas stations will begin observations on September 1, 1965. A high-speed recorder for comparison of burst structure has been added at each station.

18 mc/s. phase-switched interferometers are being put into operation at Tallahassee and at St. Osyth. The latter is, in future, to act as "Master Station" for the line.

Microfilming of records for the NASA Space Science Data Center has commenced and the Catalog of Jupiter Activity for 1961-1964 is nearing completion.

A new experiment, to study the milli-second pulses which have been observed in the Jupiter radiation, is to be conducted during the coming apparition.

1. Introduction.

Most of the period of the present report has been spent in preparation for the new observational program about to commence for the coming apparition of Jupiter. The Radio Observatory at Florida State University is being transferred to a new and quieter location several miles south of Tallahassee; a new building there is almost completed. Additional antennas for spaced-site polarization studies at 18 and 12.5 mc/s. are being constructed at Tallahassee and at the University of the West Indies in Jamaica.

A catalogue of Jupiter activity observed by the Radio Observatory and its subsidiary stations from 1961 through 1964 is nearing completion and should be circulated during the Autumn.

2. New Radio Observatory at Florida State University.

The Florida State University Radio Observatory is being transferred to a new location several miles south of the city of Tallahassee. This move is almost complete at the time of writing and it is hoped that it will be finished in time to begin observations during September, 1965. Two sections of land totalling about 12 acres have been provided by the University. The larger section of land contains most of the antennas and the building. A smaller section some 800 feet to the east has been graded and levelled for the second antenna array of a phase-switched interferometer to operate at 18 mc/s.

The new building is of concrete block construction and of area 560 sq. ft. About half the space is used for a room housing all receiving equipment; the remaining space contains two smaller rooms, a small field electronics shop, and an office. The total University investment is $10,000.

The crossed Yagi antennas have been moved to the new site. As Jupiter will be almost at the zenith at meridian transit during the next two apparitions the 16, 22, and 26 mc/s. systems have been mounted vertically and will be used as drift antennas for this period. At 18 mc/s. a new array of sixteen crossed dipoles has been constructed and this will be used for polarization observations close to meridian transit. At lower elevations the original crossed Yagi will be used mounted on a tower with adjustable alt-azimuth control. All four polarization parameters will be measured at 18 mc/s. Left and right-hand components will be measured at 16, 22 and 26 mc/s.; also at 12.5 mc/s. using a new array of four crossed half-wave dipoles for drift observations.

The phase-switched interferometer consists of two arrays of eight half-wave dipoles separated by 16 wavelengths. This instrument is to be used together with standard aural monitoring and a comparison of records taken at a subsidiary site to provide a really positive identification procedure at 18 mc/s. In addition a riometer is to be used for precise intensity measurements at the same frequency.

Arrangements are in progress for establishing the subsidiary station near Tallahassee for short baseline spaced-site studies. A site has been obtained in the National Forest area some 10 km. from the main observatory. Crossed dipole arrays at 18 and 12.5 mc/s., identical to those mentioned previously, are to be constructed here for additional polarization observations. Formal permission to use and to clear this site has been requested but has not been officially granted at the time of writing, although an assurance has been given that this will be forthcoming. A used house trailer is being refitted and modified for use as a mobile observatory at this station.

The 18 mc/s. array consists of sixteen crossed half-wave dipoles arranged in four squares as shown in Figure 1. At 12.5 mc/s. a single square of four dipoles has been used. The exact form of the polar diagrams of these arrays is not certain but this is to be measured in Jamaica with an airborne transmitter. FCC regulations prohibit this measurement in the United States.

The 12.5 mc/s. systems have been built and tested at Florida State University. One unit is shown schematically in Figure 2. The R.F. section of the switch is of conventional form using a hybrid ring with switching diodes to introduce an effective phase shift of $\pm$ 90° between the two feedlines in the two positions of the switch. The system is similar in principle to those described in the previous Report No. 6.

The 18 mc/s. systems are designed to measure all four polarization parameters and are based on the system given by Cohen (1). These, as well as the phase-switches, are being built by Aerospace Research Incorporated and a delivery date early in August has been promised.*

In the north-south line of overseas stations a standard system has been installed at Rhodes University, Grahamstown, South Africa where the radio astronomy group have collaborated for the past two years with equipment of their own. A high-speed recorder has been added to each station. These latter should greatly increase the value of the observations and only lack of funds has prevented their previous use. An 18 mc/s. phase-switched interferometer and an 18 mc/s. riometer have been added to the station at St. Osyth, England, which is, in future, to act as "Master Station" for the entire line. A 12.5 mc/s. polarimeter has also been added at St. Osyth. In a previous report it was suggested that the greater amount of 18 mc/s. radiation observed at southern hemisphere stations might be due to the fact that the predominant right-handed polarization observed at 18 mc/s. appeared to the Earth's ionosphere in opposite magneto-ionic modes in the northern and southern hemispheres. The St. Osyth polarimeter has been built to test this hypothesis as there is evidence that the proportion of left-handed polarization in Jupiter radiation increases at lower frequencies.

*Up to the time of writing this date has not be fulfilled.

The complete observational equipment of the Radio Observatory is summarized in Table 1.

3. Analysis Program

(i). Solar-Jupiter Relationships

As was pointed out by Barrow et al (2), the early cross-correlation analysis between Jupiter activity and various types of solar activity represented a gross over-simplification of this problem. For this reason the inconclusive, although suggestive results of these first studies, were hardly surprising and did not exclude the possibility of a more complex relationship.

Following a suggestion by Carr et al (3) that Jupiter activity is initiated in some manner by solar corpuscular radiation, Mr. G. M. Resch has considered the possibility of Jupiter storms being associated with solar M-regions. These M-regions are known to be long lived, i.e. several solar rotations, streams of charged particles that are emitted approximately radially from the Sun. They are swept through interplanetary space by the Sun's rotation much like spokes on a wheel and give rise to the 27 day recurrence tendency seen in geomagnetic activity.

The possible interaction of these streams with Jupiter's magnetosphere is being investigated in two ways, 1) by predicting this interaction from knowledge of when the stream interacted with the Earth's magnetosphere and the relative position of Earth and Jupiter, 2) by using the same statisitical method (Chree analysis) on Jupiter activity

that was used to show the 27 day recurrence tendency of geomagnetic activity. Using data obtained at Tallahassee together with the published data of Warwick and Kreiss (4) and of Douglas and Smith (5), Resch has made a preliminary analysis using method 1; for the major M-region events considered during 1961 the agreement between predicted and observed activity is good. A program for the IBM-709 computer is being written to facilitate analysis by the second method.

(ii). Correlation of the Motion of Satellite Io with Radio Emission from Jupiter.

A complete program for investigating the Io correlation has been written by Mr. J. Merritt and Mr. R. Lee. Using this program with 18 mc/s. observational data taken during 1961-1964 at Florida State University and its subsidiary stations it has been found that the correlation is confirmed.

(iii). Microfilming of Records for the NASA Space Science Data Center.

The Florida State University Radio Observatory is under contract (NAS 5-9838) to prepare and to edit data taken at Tallahassee and its outstations since 1961 for microfilming for the NASA Space Science Data Center. Low-speed records made at Tallahassee in 1961 and 1964 and outstation records made in 1964 have been photographed in their entirety and also by individual, labelled event. Tallahassee low-speed records of 1963 have been photographed in their entirety but not yet by individual event.

Data remaining to be photographed consists of 1963 Tallahassee low-speed records by event, 1962 Tallahassee low-speed records in entirety and by event, all high-speed polarization records from 1962, 1963, and 1964, and 1965 records of all types when taken. This represents about half the data available by June, 1966. Mr. D. Morrow is in charge of this work.

(iv). Catalogue of Jupiter Activity 1961-1964.

A catalogue of the Jupiter data is being prepared as the editing of records progresses. This catalogue includes all periods of observation and activity in Universal Time and System III Central Meridian Longitude at 18 mc/s. for each year from 1961-1964 for Tallahassee. For other frequencies periods of activity only are listed. The 1964 spaced-site observations are represented by a list of activity reported at each station and by a list of observation and activity periods for all stations combined. The combined list contains only activity observed simultaneously or nearly simultaneously at two or more stations. A smoothed occurrence probability histogram will be included for each year's 18 mc/s. observations.

4. Publications February 1, through July 31, 1965.

"A Catalogue of Jupiter Activity, 1961-1964," Morrow, D., Barrow, C.H., Resch, G.M. (In preparation for circulation during the Autumn.)

"Recommendations for Standardization of Reporting Procedures," Alexander, J.K., Barrow, C.H., Six, F. (Circular summarizing discussion session of the Jupiter Observers Conference, NASA/ University of Maryland Conference, Greenbelt, April 26-27, 1965.)

"New Horizons in Astronomy," Hyde, F.W. Chapter in Astronomical Year Book, 1966. (Eyre and Spottiswood, London. (In press.)

"Amateur Radio Astronomy," Resch, G.M. and Barrow, C.H. Note for private circulation to the various radio amateurs who frequently consult the Radio Observatory.

Talks given during the period:

C. H. Barrow

"Jupiter Observations at Florida State University." NASA/ University of Maryland Conference, Greenbelt, April 26-27, 1965.

Chairman, Discussion Session on "Possible Standardization of Reporting Procedures." NASA/ University of Maryland Conference, Greenbelt, April 26-27, 1965.

"Radio Observations of Jupiter at Florida State University." Florida Academy of Science Meeting, Tallahassee, March 12, 1965.

F. W. Hyde

"Radio Emission from Jupiter and the Satellite Io," British Astronomical Association Meeting, London, February 24, 1965.

"Recent Advances in Radio Studies of Jupiter," British Astronomical Association Meeting, London, May 26, 1965.

"Radio Studies of Jupiter," Colloquim, University of Essex, Colchester, England, December, 1964. (Not previously reported.)

In preparation:

Papers for S. E. Section, American Physical Society Meeting, Charlottesville, Virginia, November, 1965:

"A Catalog of Jupiter Activity, 1961-1964, Morrow, D., and Barrow, C.H.

"Solar-Jupiter Relationships," Resch, G.M.,and Barrow, C.H.

5. Personnel Working on the Grant:

(a.) Tallahassee

C. H. Barrow, Assistant Professor and Principal Investigator

R. Lee, Graduate Assistant

D. Morrow, Graduate Assistant

G. M. Resch, Graduate Assistant

*J. H. Cocke, Electronics Technician

L. McCord, Electronics Technician

G. R. Adcock, Undergraduate Assistant

*K. Peale, Undergraduate Assistant

J. Merrit, Undergraduate Assistant

*N. Hazelwood, Undergraduate Assistant

*Terminated during the period.

(b.) St. Osyth

F. W. Hyde, Radio Engineer and Director of St. Osyth station (Self supported.)

R. Womble, Undergraduate Assistant

D. Crosswell, Part-time Secretary

Personnel Associated with the Project:

(a.) Grahamstown, South Africa

E. E. Baart, Senior Lecturer in Physics and Director of Radio Astronomy.

M. C. Bosch, Graduate Assistant

G. M. Gruber, Graduate Assistant

(b.) Local supervisors for the 1964 spaced-site observations.

R. W. Morriss, Lecturer in Physics, University of Ibadan

J. Catala, Professor of Physics, University of Valencia

H. Torgerson, Engineer, Technical University of Trondheim

Groups of from 3 to 5 undergraduate assistants were employed on the Grant at St. Osyth, Ibadan, Valencia and Trondheim during the period August 1 through December 15, 1964.

6. Future Plans.

Dr. E. E. Baart, Director of the Rhodes University Radio Astronomy Group, is to visit Florida State University for the whole of the Fall Trimester. During his visit he proposes to use the Radio Observatory facilities for an experiment to study the milli-second pulse-type noise bursts which some workers have recorded from Jupiter. Observations are to be made at several separated frequencies with the 8-channel High Speed recorder operating at about 125 mm/sec. Left and right-hand components will be recorded at one frequency (probably 18 Mc/s.) from a two receiver and hybrid ring system (Barrow (6) to avoid switching techniques which might confuse the appearance of the very short duration bursts. A null antenna will also be used.

Dr. Baart will be supported by a Carnegie Fellowship during his visit.

An additional observing frequency is to be added at

about 14 Mc/s. so that activity and intensity may be better compared in the frequency range 18-12.5 Mc/s. Observations will be taken from this new 14 Mc/s. system and also from the existing systems at 12.5,16, and 18 Mc/s. The frequency range 12.5-16 Mc/s. in particular, has received relatively little attention so far. Noise checks close to 14 Mc/s. are in progress at the time of writing.

The facilities of the St. Osyth station are being used by Dr. A. Hewish of the Mullard Radio Observatory, Cambridge University, as part of a spaced-site experiment. Three standard systems are being installed at 81 Mc/s. in an attempt to detect motion of the interplanetary medium. one of the systems has been located at St. Osyth and is being attended by Mr. F. W. Hyde. Dr. Hewish is a Consultant for Grant NSG-224-61.

7. Visitors.

Professor J. A. Gledhill (Rhodes University, South Africa), Professor R. W. H. Wright (University of the West Indies), and Dr. Frank Six (Brown Engineering Corporation and late of the University group) have recently visited the Radio Observatory. Dr. A. Hewish (Cambridge University) has visited the St. Osyth station several times in connection with the experiment mentioned in the previous section.

References

1. Cohen, M. H. Proc. I.R.E., 46, 183 (1958).

2. Barrow, C.H., Resch, G.M., Hyde, F.W., Gruber, G.M., Bosch, M.C., Nature, 204, 637 (1964).

3. Carr, T.D. Smith, A.G., Bollhagen, H. Six, F., Chatterton, N.E. Astrophys.J., 134, 105 (1961).

4. Warwick, J.W., and Kreiss, W. T., I.G.Y. Solar Activity Report Series, No. 28, November 2, 1964.

5. Douglas, J.N. and Smith, H.J., Astron. J., 68, 163 (1963).

6. Barrow, C.H. Astrophys. J., 135, 847 (1962).

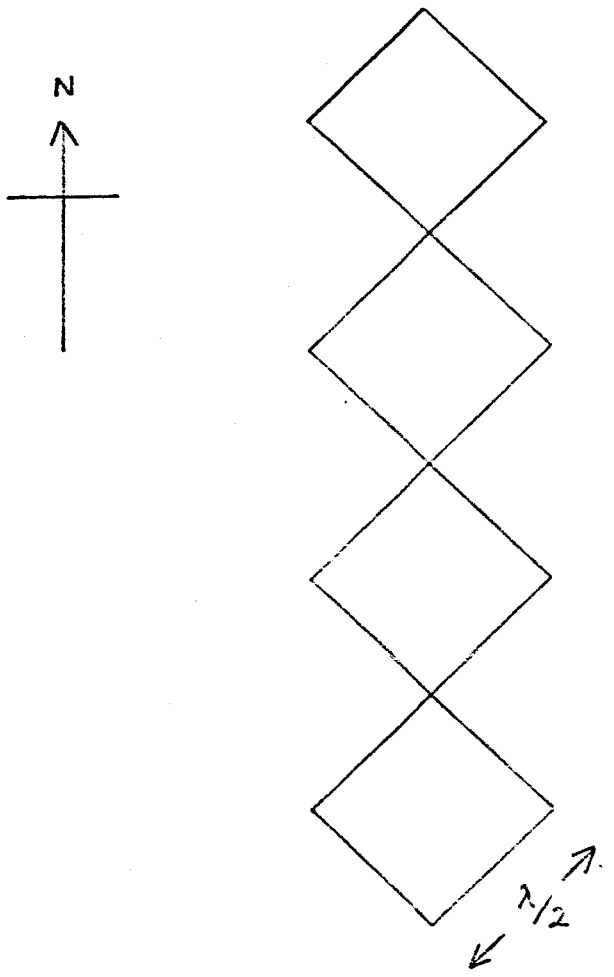

Figure 1. The 18 mc/s crossed dipole array.

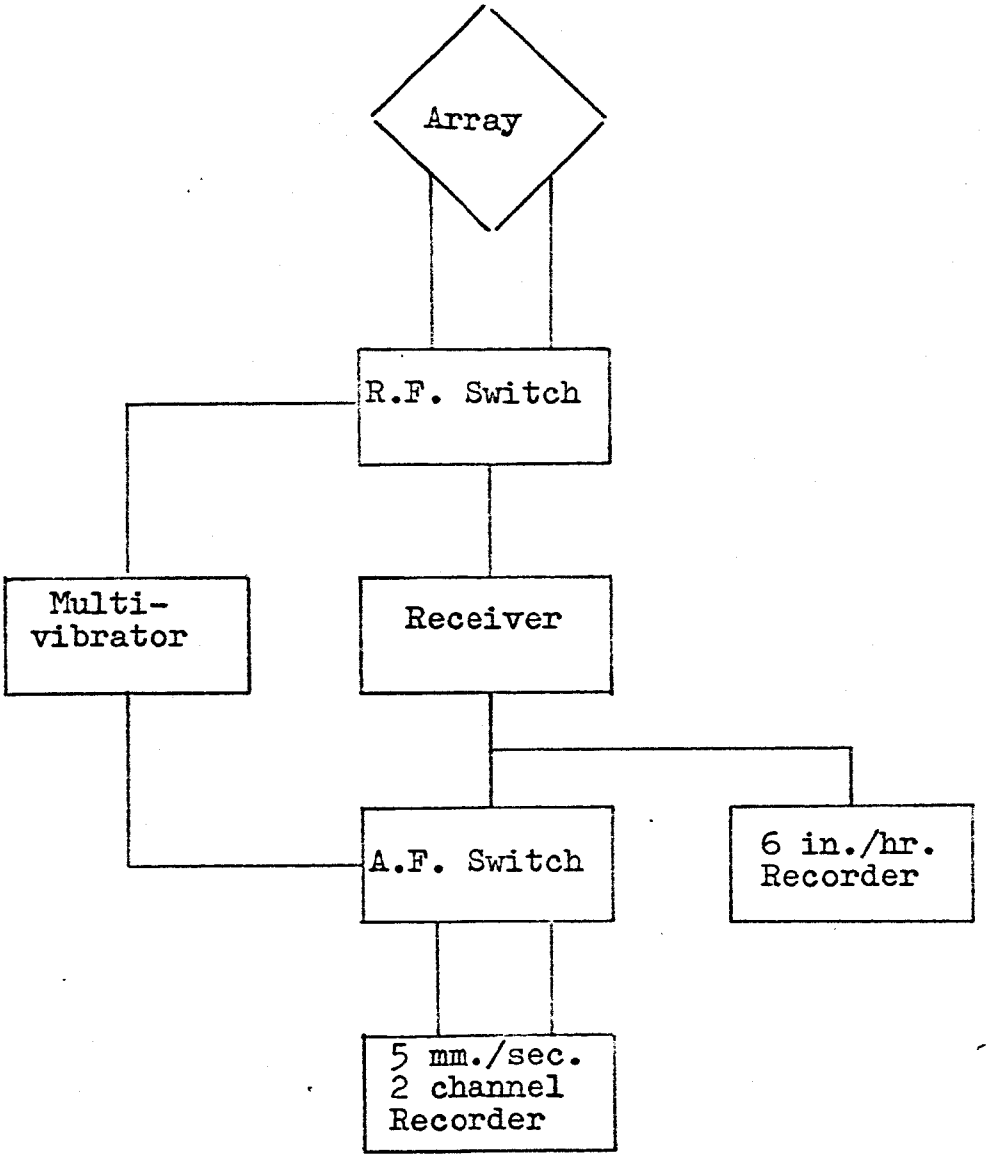

Figure 2. Schematic of the 12.5 mc/s polarimeter.

F.S.U. Radio Observatory Installations, 1965

f(Mc/s.)	Tallahassee		University of the West Indies, Jamaica	St. Osyth, England	Norway, Spain, Nigeria South, Africa
	Main Observatory+	Subsidiary x Station			
18	4 Parameter Polarimeter	4 Parameter Polarimeter	4 Parameter Polarimeter		
18	Phase-switched Interferometer			Phase-switched Interferometer	
18	Riometer			Riometer+	
				Standard Unit*	Standard Unit*
12.5	2 Parameter Polarimeter	2 Parameter Polarimeter	2 Parameter Polarimeter	2 Parameter Polarimeter	
16	2 Parameter Polarimeter				
22	2 Parameter Polarimeter			Corner Reflector	
26	2 Parameter Polarimeter				

*Standard Unit consists of alt-azmuthally mounted 4-element Yagi, receiver, recorder, high-speed recorder and calibrator. Operative as from September 1, 1965.

+Operative as from October 1, 1965.

xOperative as from November 1, 1965.

Table 1.